

# Disasters on Earth Observations from Space Systems on the Cloud

Sang-Ho Yun<sup>1</sup>, Susan Owen<sup>1</sup>, Hook Hua<sup>1</sup>, Cunren Liang<sup>2</sup>,  
Jungkyo Jung<sup>1</sup>, Piyush Agram<sup>1</sup>, Frank Webb<sup>1</sup>, Mark Simons<sup>1,2</sup>,  
Paul Rosen<sup>1</sup>, Gerald Manipon<sup>1</sup>, Lan Dang<sup>1</sup>, Eric Fielding<sup>1</sup>, Eric  
Gurrola<sup>1</sup>, Gian Franco Sacco<sup>1</sup>, Justin Linick<sup>1</sup>, Namrata Malarout<sup>1</sup>

1. Jet Propulsion Laboratory, California Institute of Technology

2. California Institute of Technology

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement by the United States Government or the Jet Propulsion Laboratory, California Institute of Technology.

Background: 2013 EUMETSAT

<https://www.flickr.com/photos/eumetsat/10726056545/in/photostream/>





Integrating  
Space Geodesy  
Seismology  
Modeling



Examples from the 2011 M9.0  
Tohoku-Oki (Japan) earthquake

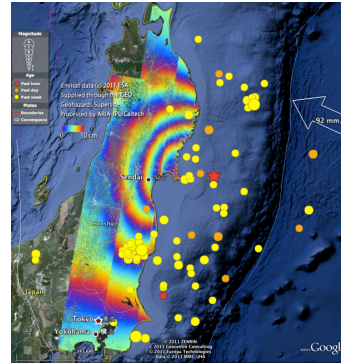
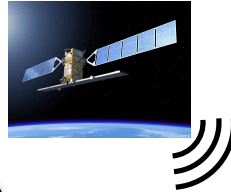
Radar  
Sensors

GPS  
Networks

Seismic  
Networks

Optical  
Sensors

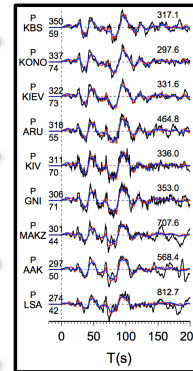
Automated  
Data Collection  
& Processing



Radar



GPS



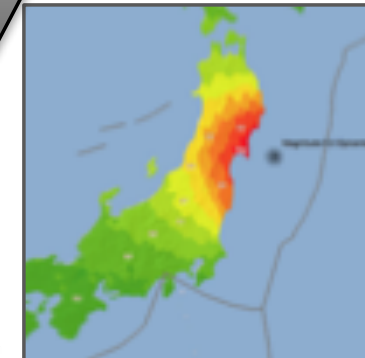
Seismology



Monitoring &  
Near Real-Time  
Assessment



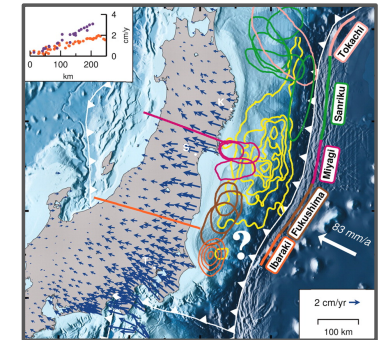
Building Damage  
& Inundation



Permanent  
Ground Deformation

"This is exactly the  
kind of product we  
are looking for."

Anne Rosinski  
Calif. Geol. Survey



High-Resolution  
Hazard Assessment  
from Fault Models

Potential  
Partners



esa

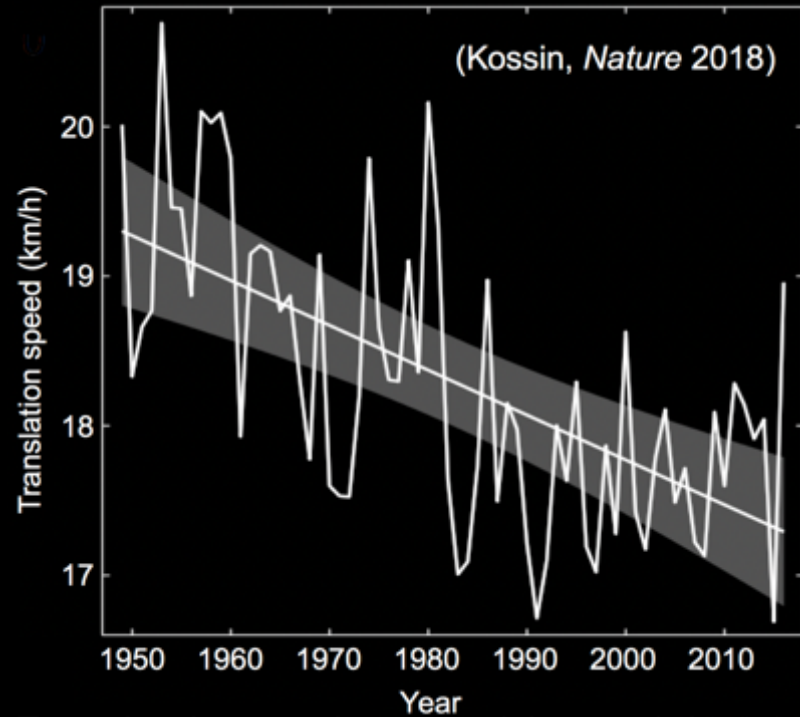


"We have high  
hopes for ARIA."

Keiko Saito  
World Bank



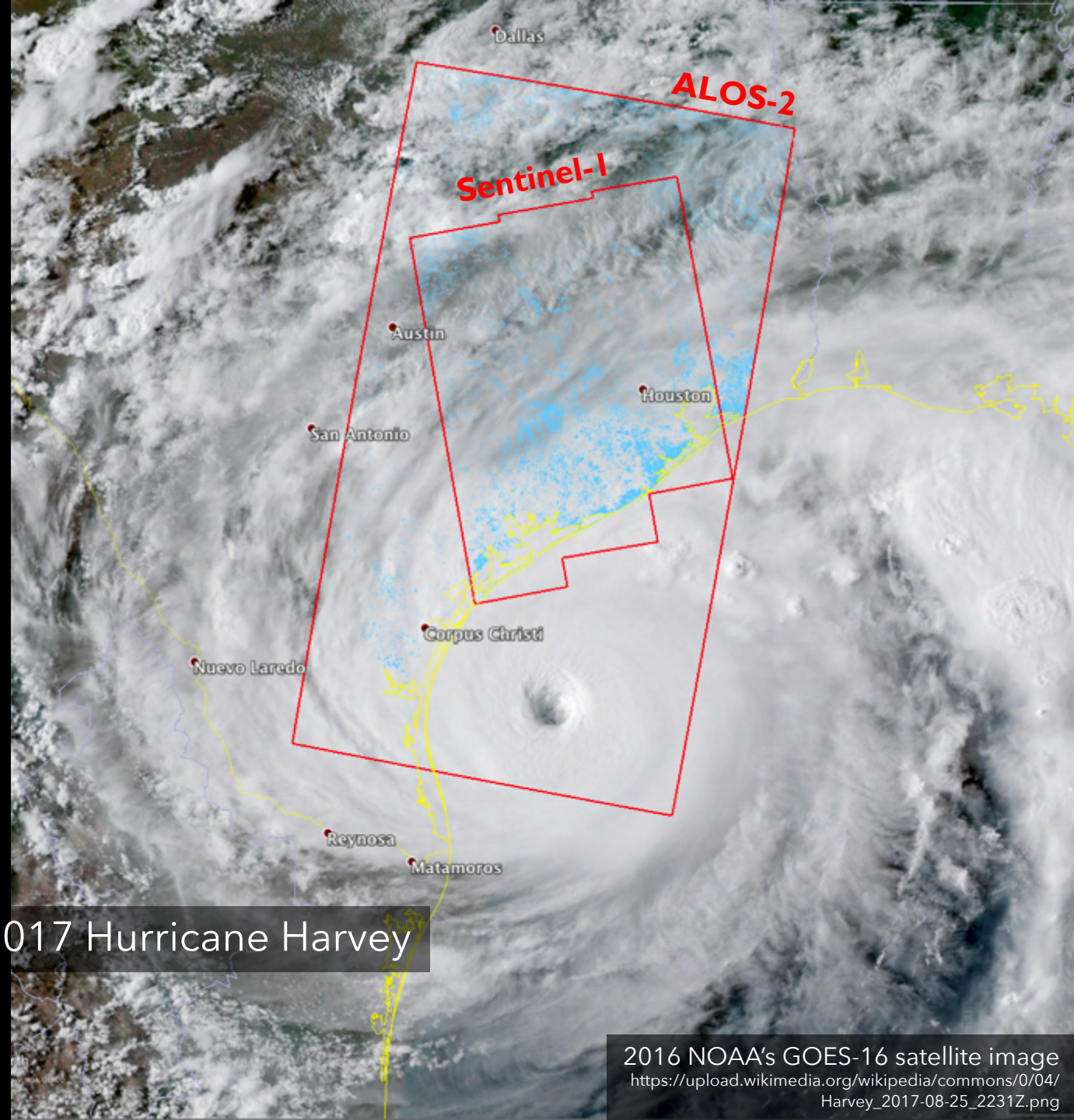
# Slowdown of Tropical-Cyclone Translation Speed



Speed decreased during 1949-2016:

- Globally by 10%
- North Atlantic by 20%
- Western North Pacific by 30%

2017 Hurricane Harvey



2016 NOAA's GOES-16 satellite image  
[https://upload.wikimedia.org/wikipedia/commons/0/04/Harvey\\_2017-08-25\\_2231Z.png](https://upload.wikimedia.org/wikipedia/commons/0/04/Harvey_2017-08-25_2231Z.png)



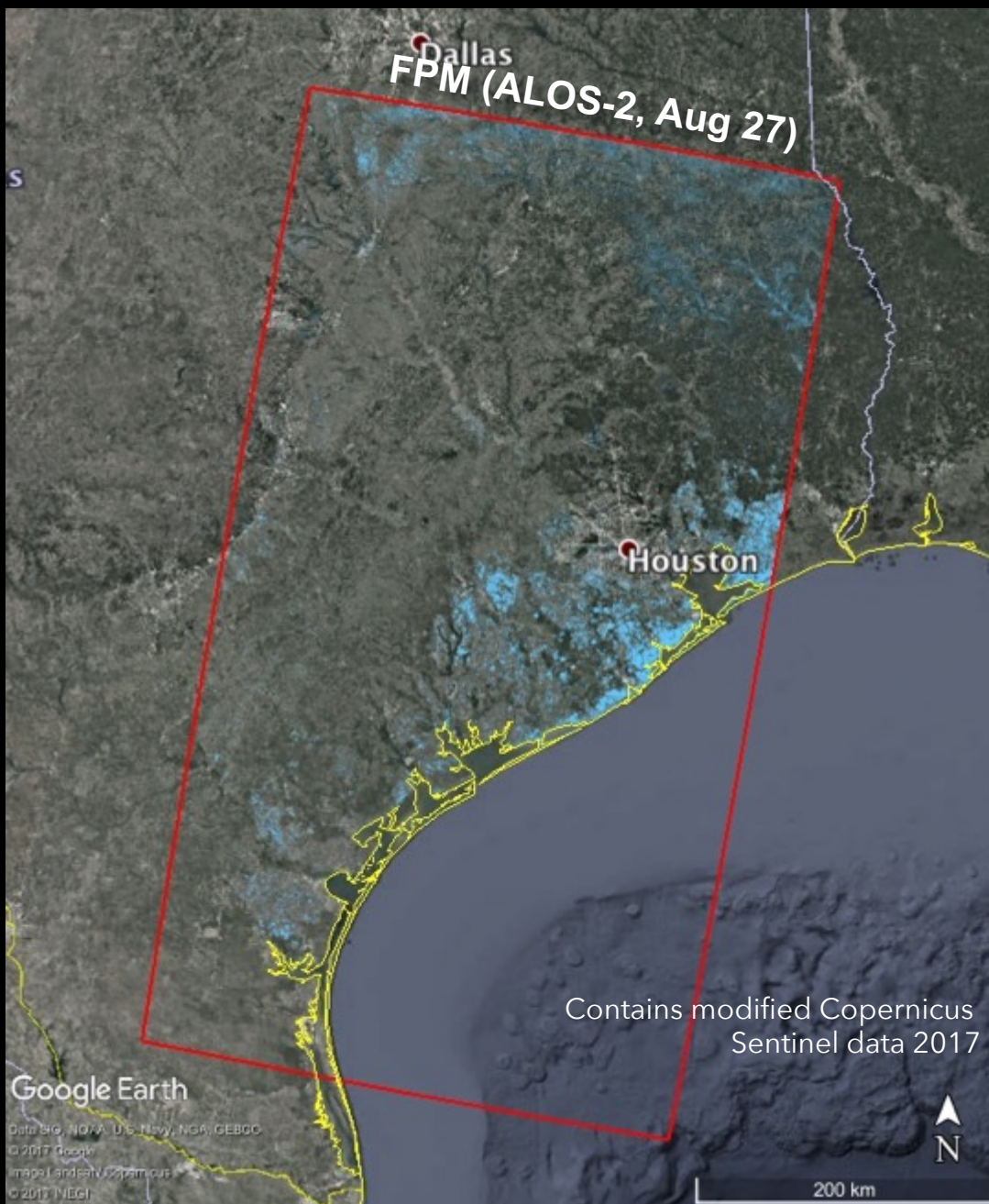
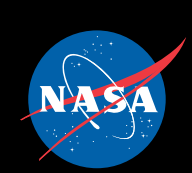


# 2017 Hurricane Harvey

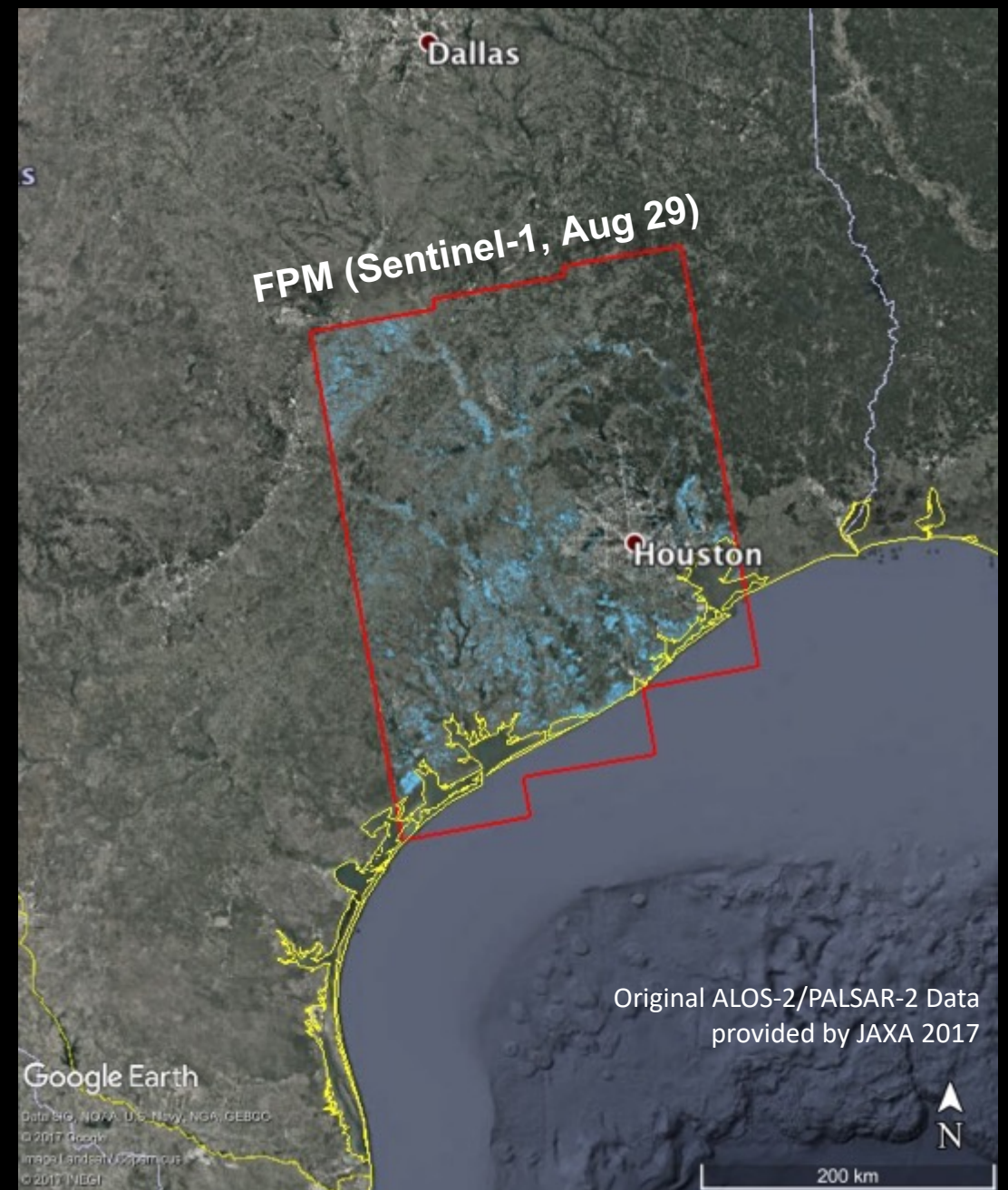
- Category 4 at landfall
- 60" (152 cm) rainfall







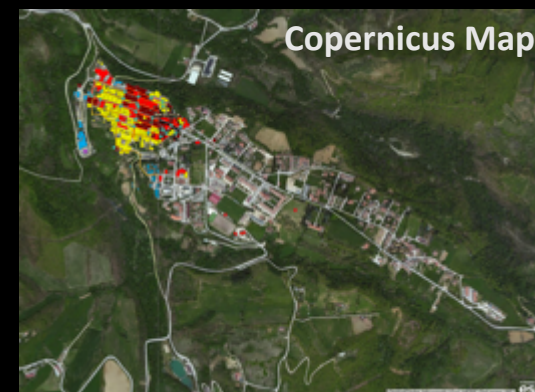
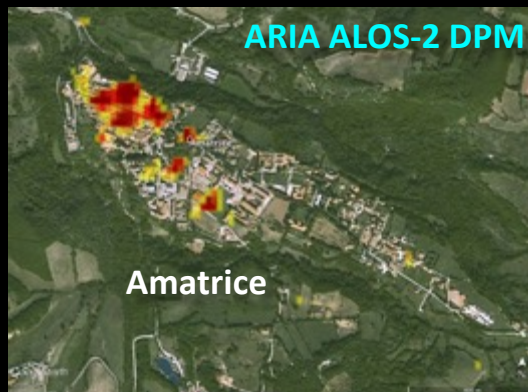
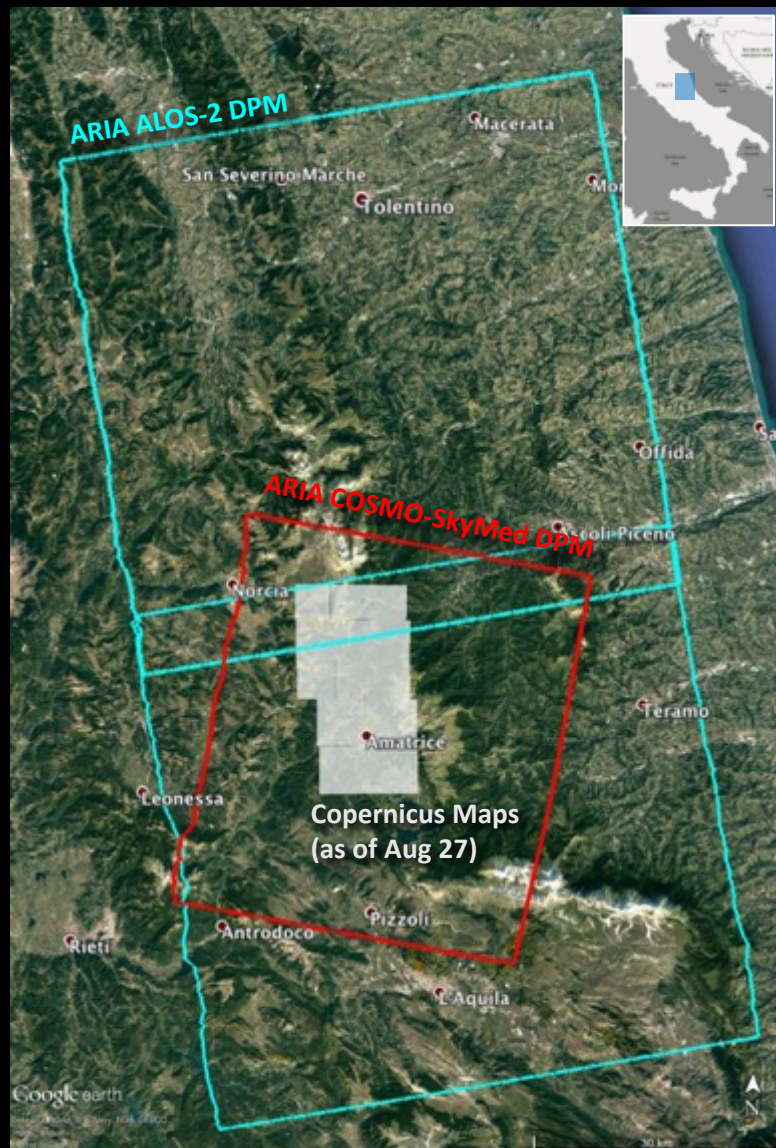
<https://photojournal.jpl.nasa.gov/catalog/pia21931>



<https://photojournal.jpl.nasa.gov/catalog/pia21932>



# Amatrice Earthquake (M6.2 Aug 24, 2016), Italy

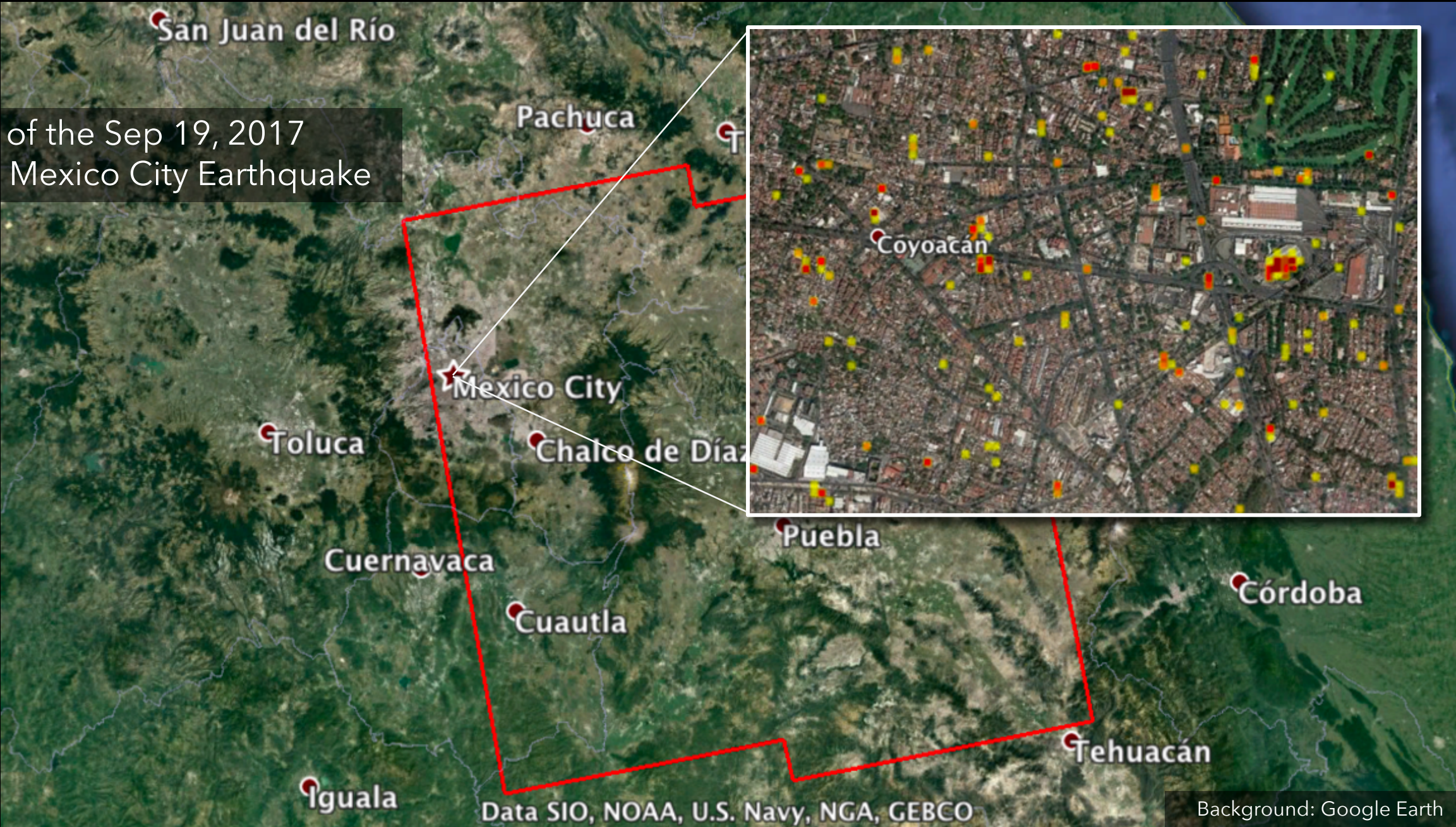


<https://www.nasa.gov/feature/jpl/nasa-produced-maps-help-gauge-italy-earthquake-damage>



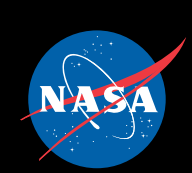


DPM of the Sep 19, 2017  
M7.1 Mexico City Earthquake



<https://www.nasa.gov/feature/jpl/nasa-produced-damage-maps-may-aid-mexico-quake-response>





# DPM vs Ground Observation (M7.1 Mexico City Earthquake)



DPM



Source: Google Street View

Before



Source: www.adn40.mx

After

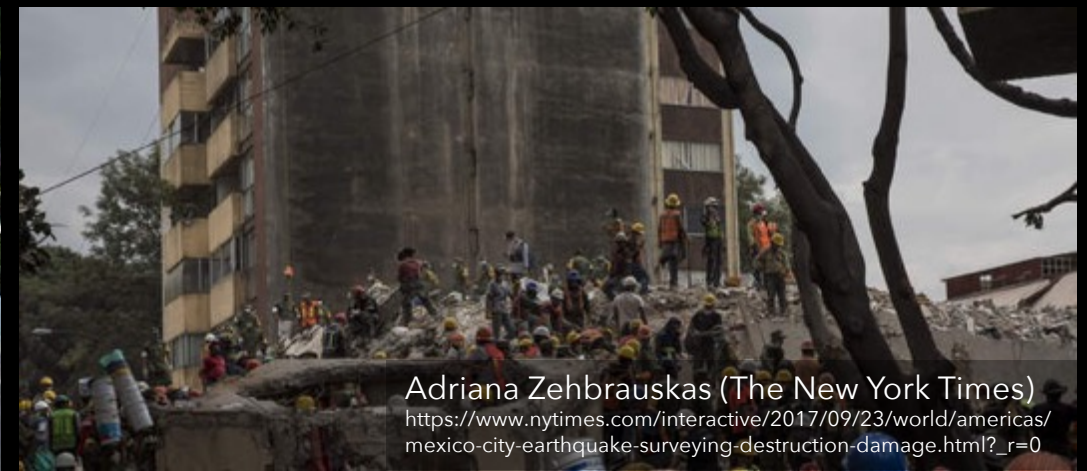


DPM



Source: Google Street View

Before



Adriana Zehbrauskas (The New York Times)  
[https://www.nytimes.com/interactive/2017/09/23/world/americas/mexico-city-earthquake-surveying-destruction-damage.html?\\_r=0](https://www.nytimes.com/interactive/2017/09/23/world/americas/mexico-city-earthquake-surveying-destruction-damage.html?_r=0)

After



"We estimated that Louisiana would have about 27,000 damaged homes, but it was through the acquisition of SAR data and other remotely sensed data that we were able to see that it was a much larger impact than we had forecast."

Glenn Russell, FEMA  
After the August 2016 Louisiana Floods

"It is so fascinating to see this map. The pattern of the distribution of red areas correlate with most realities on the ground."

Indra Sharan, OFDA, USAID  
From Nepal after the M7.8 2015 Gorkha Earthquake

"During our reconnaissance missions we have used damage proxy maps (DPMs). ... My findings clearly show that the DPM published right after the event was very effective in defining collapsed buildings."

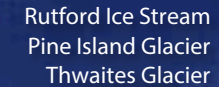
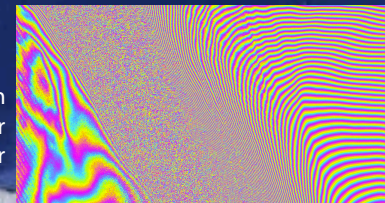
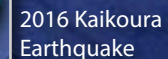
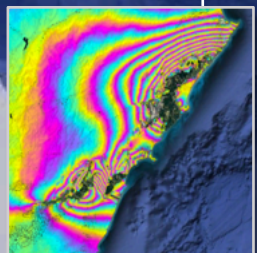
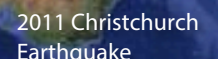
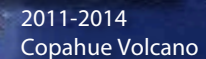
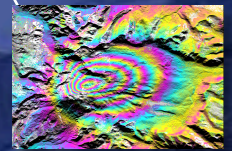
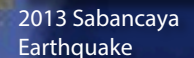
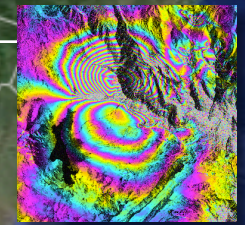
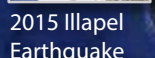
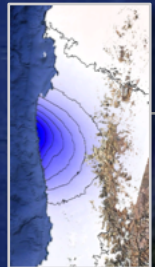
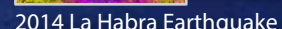
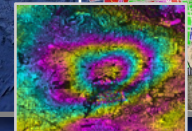
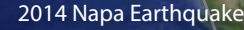
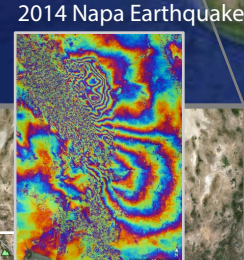
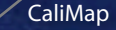
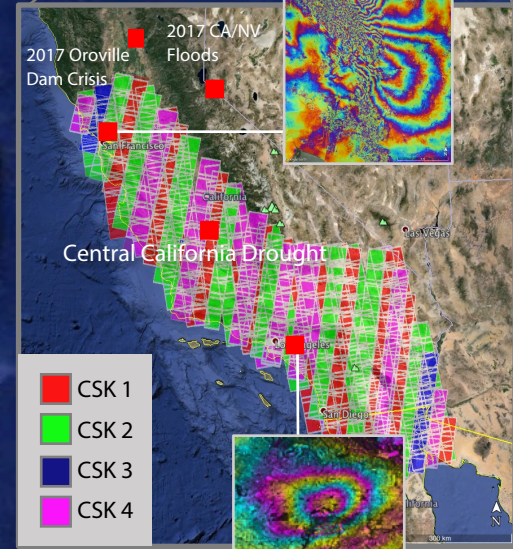
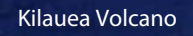
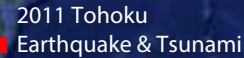
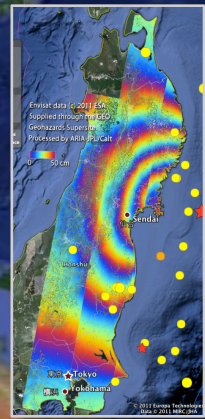
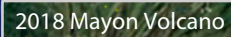
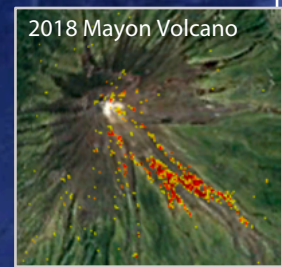
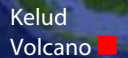
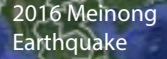
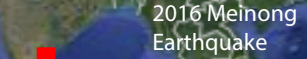
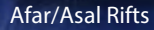
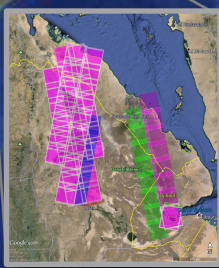
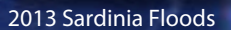
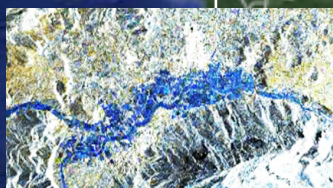
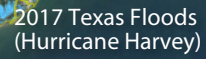
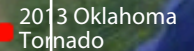
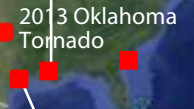
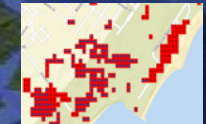
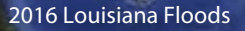
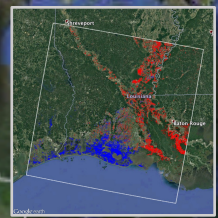
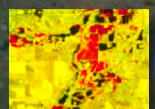
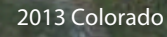
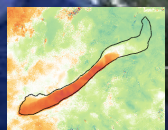
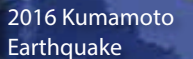
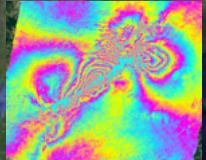
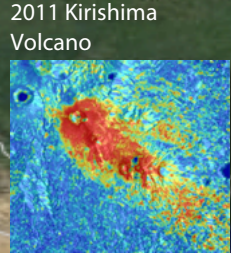
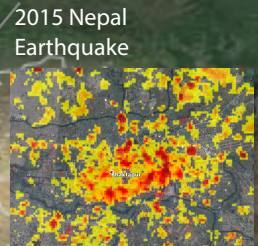
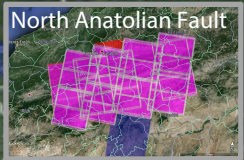
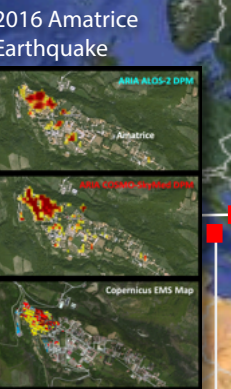
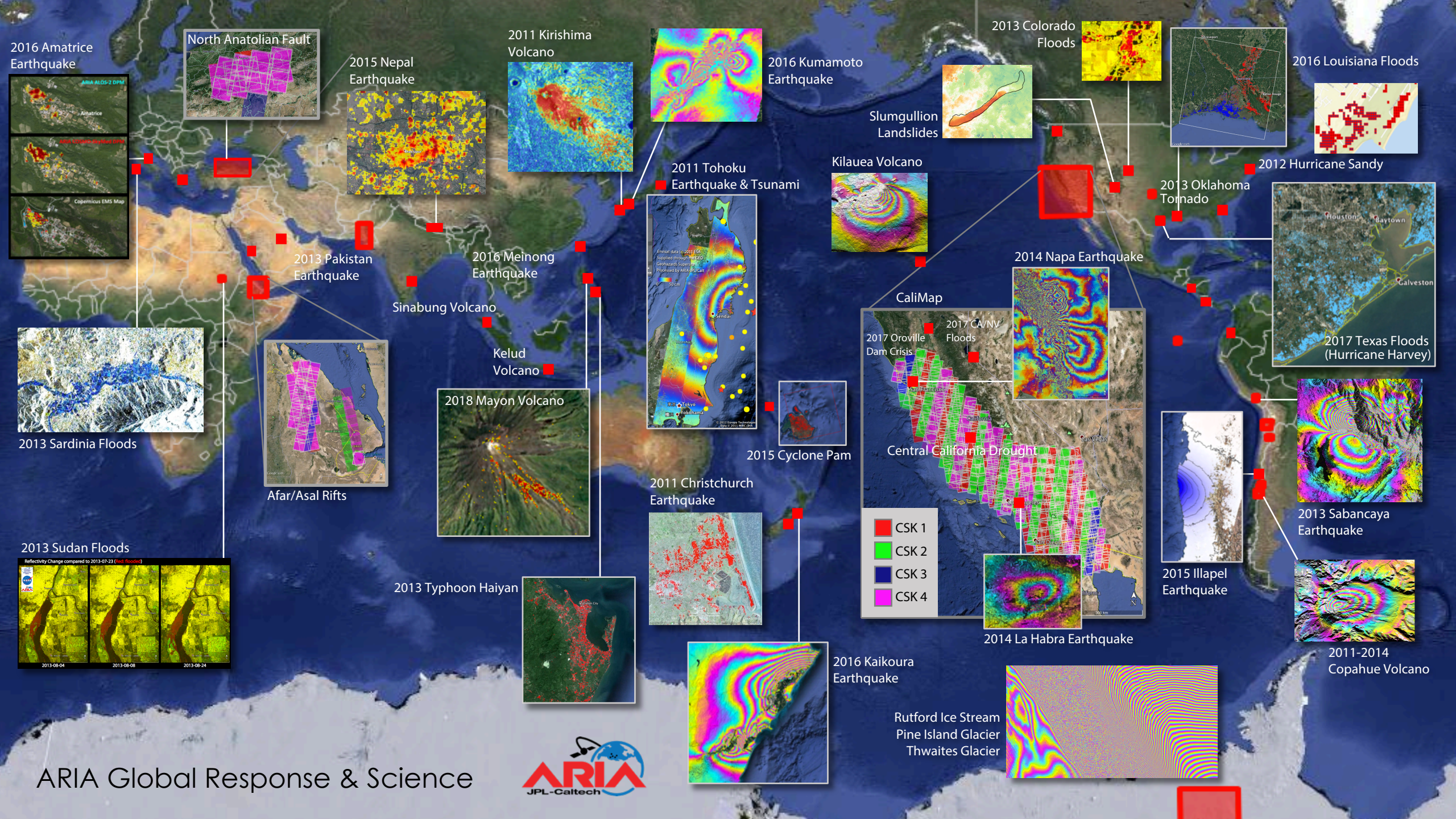
Paolo Zimmaro, UCLA/GEER  
After GEER fieldwork of the 2016 Central Italy earthquakes

"After the tragic August earthquake in Amatrice, Italy, NASA's JPL produced maps of the greatest damage. These sophisticated maps will be used in the rebuilding efforts."

Barack Obama, Former President of the US  
At the White House with Matteo Renzi on Oct 28, 2016











**JPL**  
**ARIA**

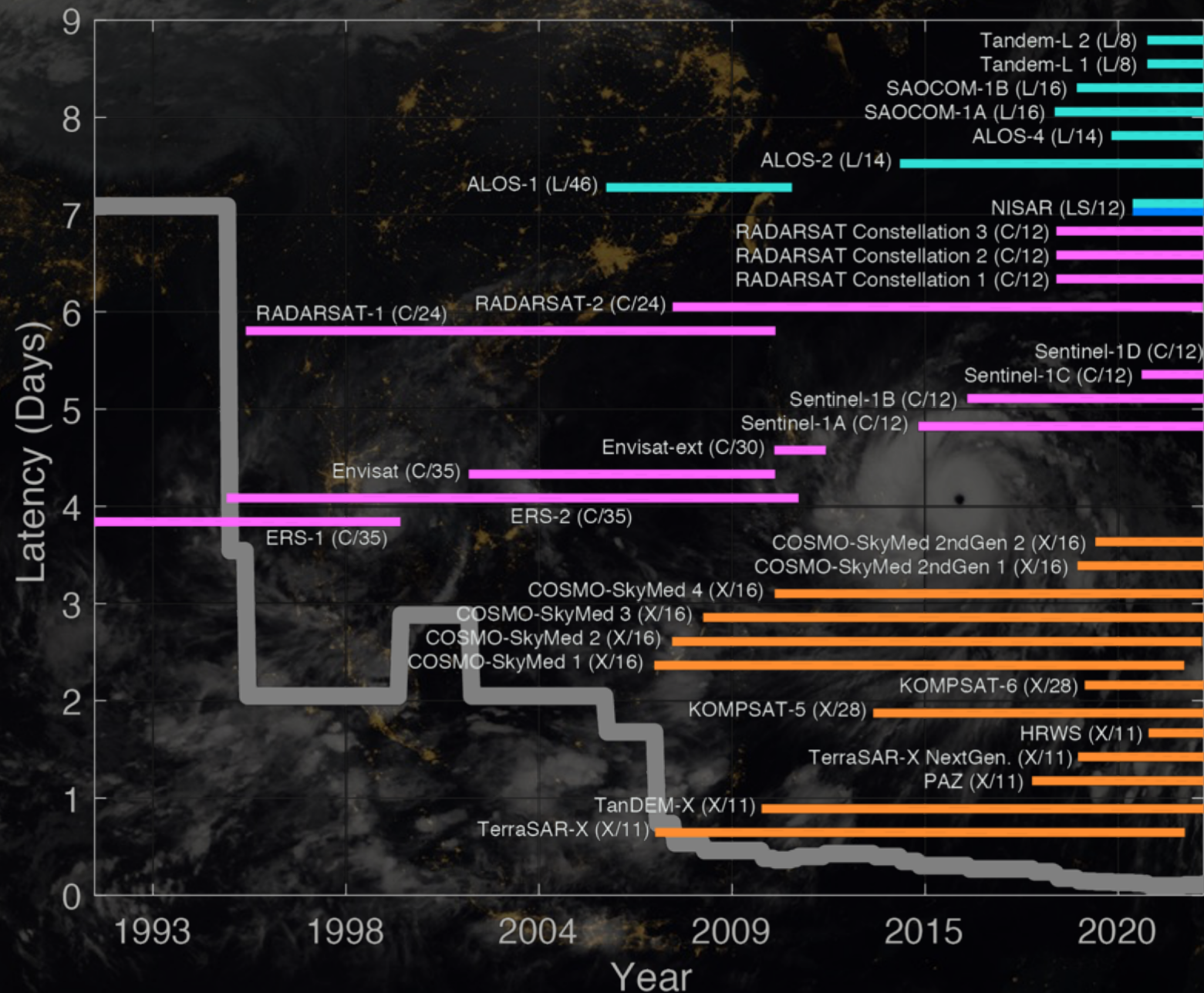


**ARIA-SG**



# International SAR Satellites Overpass Latency

Current missions: 6 hours  
S1 & CSK & A2: 10 hours  
S1 & CSK: 12 hours  
S1: 30 hours





# Summary, Challenges, and Opportunities

The ARIA systems is being automated for rapid disaster response. ARIA's FPMs and DPMs that are being used by responding agencies around the world.

FPM2 and DPM2 algorithms are being developed using PolInSAR time series analysis.

SAR data download is the biggest bottleneck

→ Discussing with EOS and Amazon Singapore for Sentinel-1 SAR data ingestion